CONF-7809117--1

MASTER

LA-UR-78-3328

TITLE: Rational Economic Strategy and Entropic Analysis

AUTHOR(S): John C(aldwell) Allred, MP-DO and University of Houston

Hillard H(ays) Howard, H-1

SUBMITTED TO: To be published in proceedings of a Workshop on Dissipative Structures in the Social and Physical Sciences

los alamos
scientific laboratory
of the University of California
LOS ALAMOS, NEW MEXICO 87544

An Affirmative Action/Equal Opportunity Employer

Form No. 836
St. No. 2629
1/75

UNITED STATES
ENERGY RESEARCH AND
DEVELOPMENT ADMINISTRATION
CONTRACT W-7405-ENG-36

RATIONAL ECONOMIC STRATEGY AND ENTROPIC ANALYSIS

John C. Allred* and Hillard H. Howard

Los Alamos Scientific Laboratory
Los Alamos, NM 87545

ABSTRACT

The neglect of entropic changes of energy and matter in the economic process leads to incorrect formulation of economic theory, as was first pointed out by the economist, Nicholas Georgescu-Roegen.

Entropic analysis, that is, the reckoning of entropic changes in real-world processes, appears to be a useful guide toward a realistic understanding of the economic process.

The example chosen here is the choice between natural gas and coal as fossil fuel. An outline of the necessary analysis is discussed, together with the requirements of rational economic strategy.

*Professor of Physics and Biophysical Sciences, University of Houston (on leave).

RATIONAL ECONOMIC STRATEGY AND ENTROPIC ANALYSIS

John C. Allred* and Hillard H. Howard
Los Alamos Scientific Laboratory
Los Alamos, NM 87545

Nicholas Georgescu-Roegen, the noted economist, has often pointed out in his writings that the economic process is entropic. By this statement he means that the economic process must be understood in terms of changes of form or of structure of matter and of energy. This idea is in contradistinction to the implication of standard economic theory if the terms "production" and "consumption" are taken literally. Since neither matter nor energy is either created or destroyed, production and consumption do not in fact occur in a physical sense. Transformations of matter and energy among their various states must thus be intimately related to the economic process.

With his provocative aphorisms, "matter matters too" and "you can never use the same matter twice," Georgescu-Roegen has drawn attention to the continual dissipation of matter as it participates in real-world processes.

Although Georgescu-Roegen is controversial among economists, we agree with him that the failure to take note of the entropic nature of the economic process leads to erroneous economic theory. In this paper we discuss some ways in which entropic analysis can contribute to correct economic theory. The qualitative approach taken here does not negate the validity of the quantitative approach to the problem. Our assumption of the importance of entropic analysis is based upon the importance of the second law of thermodynamics.

*Professor of Physics and Biophysical Sciences, University of Houston (on leave).

Since the evolution of the universe depends upon the entropy gains and losses of its systems, we must kee entropic accounts if we are to understand processes and their consequences co y. We discuss here one portion of the energy problem confronting the worl illustrate the application of entropic analysis. With respect to the energy crisis, how does one construct a rational strategy?

First, a rational strategy must take into account the national goals which are selected by the political process, itself entropic as pointed out by Allred.[1] Among these might be the choice of a desired gross national product, a given growth rate, a stable economy, perhaps even a shrinking demand on energy resources.

A rational strategy must take into account the availability of both fuels and of materials required for the construction of energy-producing plants and the distribution of the resulting energy.

A rational strategy must strive for maximal achievement of goals with minimal harm to the population and to the environment.

Once arrived at, a rational strategy must be as valid tomorrow as it is today. Changes in the parameters are necessary as the availability of resources changes, but the validity of the strategy on any given day should not be questionable. The strategy should not be dependent on the whim of government. Indeed, if the strategy is rational, the government should be guided by it; therefore, the government would not act upon whim.

Finally, a rational strategy should be self-evident in the sense that rational men would agree upon it in the same way that rational scientists can agree upon the validity and the result of a scientific experiment. What we are saying is, given the goals, the strategy for arriving at these goals should be clear and self-evident to rational and thoughtful people.

An instance of the sort which we believe can be avoided appeared in The Wall Street Journal for Thursday, November 16, 1978, in which it is reported that "Secretary of Energy James Schlesinger told a news conference that he expects a short-term surplus of natural gas due to the federally mandated gas-price increases that take effect December 1, and that 'we wish to burn all the gas that we can in the short run to hold down oil imports.'" The story goes on to say that "the emphasis on burning gas runs counter to one of the key goals of Mr. Carter's energy program, expressed over an eighteen month period, which was to switch industrial fuel users to coal and other abundant fuels from both oil and natural gas.

"But Mr. Schlesinger said that, in carrying out the new energy law as it applies to existing plants, the department would be stressing in the short run another of the program's 'hierarchy of objectives'--the need to reduce oil imports."

We would suggest that the above is an example of irrational strategy. When the Secretary changes his mind, millions and billions of dollars must be reallocated in capital costs. This is not rational economics.

What can entropic analysis contribute to this decision-making process? In particular, can it shed any light on the question of whether one should choose to burn coal, or oil, or natural gas? Here we outline the steps which one would take in an entropic analysis of this problem.

The entropic analysis must first deal with the availability of the fuels and the negentropic cost of acquiring them. The problem is one of removing a store of chemical compounds from one place--the mine or the wellhead--and causing this material to move to a place at which it is desired. The process is negentropic, that is, it consists of localizing a fuel in the desired position as contrasted to all possible locations in which it might exist.

One must next look at the elemental and chemical composition of the fuel. The fuels plus their effluents are both composed of carbon, hydrogen, nitrogen, sulfur, oxygen and sometimes other elements. In the case of coal, uranium and thorium and other heavy metals may be included.

The chemical structure of the fuels must be considered, especially as to whether the hydrocarbons are aliphatics or aromatics. Aromatics are known to be teratogens and carcinogens. What is often overlooked is that some of the aromatics in coal are distilled out of the coal and not burned and therefore enter into the environment in their original state. Their dispersal may have serious entropic consequences to the environment and the population.

Some of the products of combustion are carbon dioxide, water, NO_x, sulfur dioxide, hydrogen sulfide, and the radioactive and heavy metals listed above. At this point, the question arises as to the tolerance of the environment and the population for these effluent wastes. In some cases these effects on organisms are known by experiment. It is also possible to understand them on an entropic basis if one studies the degree of disruption of the molecular structure of molecules such as DNA or enzymes, and the effects on organ structure, such as scarring.

It is sometimes argued that the entropic changes in the environment are small, and therefore should be unimportant. This in fact does not agree with experience. The reason is, we believe, that all living organisms have a multiplicity of regulatory and feedback mechanisms. Hormone systems, the immune system, and nerve circuits serve to illustrate these feedback loops. Organisms maintain homeostasis by these regulatory mechanisms. A small disruption of nerve membrane or enzyme or DNA or hormone leads to very large effects, perhaps even the destruction and death of the organism. The changes of entropy involved, while small, can be quantitatively known.

Another factor to be considered in the entropic analysis of the problem is the plant efficiency. Here one must consider the total entropic burden resulting from the production of one unit of energy, say a kilowatt-hour. One begins with the heats of combustion of the various fuels and seeks a rational way to compare the efficiencies of processes which convert energy of combustion into the desired form of energy. The appropriate approach has already been recognized in the calculation of "second law efficiencies" for processes in finite time.

Another factor which has only recently been recognized is the negentropy of capital equipment. Berry[2] and Allred,[3] independently, have made a start on this problem. The question which they address is the negentropic cost of construction of capital equipment. It is perhaps a tautology to say that a surface is the interface between one part of a machine and another, or the interface of the machine to the rest of the world. Berry and Allred have both asked the question of the cost of producing machined surfaces in negentropic units; Berry calculates the free energy cost of production of all the machined-surfaces in an automobile as about 10^{-10} kilowatt-hours. One interpretation of this result is that the worn-out automobile is repairable for the expenditure of such a trivial amount of energy. Experience negates this interpretation. We find this an intriguing paradox and feel certain that the question is far from settled.

The guiding surfaces of machines, such as bearings, appear to have something in common with feedback loops. We think there may be a connection between this idea and the earlier one of feedback systems in living organisms.

It appears to us that a rational strategy would guard against large local increases in entropy. The notion of something being a pollutant is related to our understanding of entropy. If the byproduct of a process is useable in another process we no longer think of it as a pollutant, but rather we make an effort to reclaim it. However, if the byproduct is not useable, it is a pollutant. The entropy of a fuel is a measure of the content of energy available to do work--i.e., usefulness. The similarity between the negentropic content of a material and its usefulness is also striking. Therefore, unless we wish to fill a locale with useless matter and energy we must guard against large increases in entropy at that location. Perhaps an understanding of this principle would have alleviated some of the problems with the streams and lakes near industrial sites.

As here proposed, entropic analysis is a dynamic technique. That is, it recognizes automatically the increasing difficulty of acquiring materials and fuels as the process progresses. It is thus unlike standard economic models which quite usually assume static, closed systems. As the availability of fuels and materials changes, so will the negentropic costs, and so will the parameters of the rational strategy derived from entropic analysis.

To be specific, suppose it should appear that natural gas is presently the fuel of choice, as Secretary Schlesinger now says. Even if supplies are very large, new natural gas wells must go deeper, and thus expand the capital requirements and negentropic costs for additional fuel. It is possible that sooner or later the negentropic costs will exceed those of other fuels and the preferred mix will change. We emphasize, however, that if this change occurs it will not be because OPEC ministers have a meeting or because the Secretary changes his mind, but because a physical and chemical analysis of the problem leads to different parameters of the strategy.

Why can't the free market make these choices? The fact that it is regulated by the government insures that the market is not free, and so the preceding question may be redundant. More to the point, though, the free market operates correctly and efficiently only in the presence of perfect information. At present, that part of the information relating to the negentropic capital costs of energy converters is missing, because our economy has until very recently assumed that energy is almost a free good. At a minimum the market needs this missing information to function properly. We think the sound theoretical basis for a rational strategy offered by entropic analysis will ameliorate the painful alternative of learning only by experience.

REFERENCES

1. Unpublished note 1978.

2. R. Stephen Berry, Bull. At. Sci. pp. 8-15 (April, 1972).

3. Hillard H. Howard, Second Law Concepts and Energy Converters, Proceedings of Entropy-Economic Symposium pp. 27-30, Biophysical Research Corp., Houston, 1977.